

SECTION 02651- STEEL PIPE, LINED AND COATED

City of San Diego, CWP Guidelines

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NTS: This Section is coordinated with Section 02600 such that it requires inclusion of that Section in the Contract Document.

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PART 1 -- GENERAL

1.1 WORK OF THIS SECTION

- A. The WORK of this Section includes providing lined and coated steel pipe, including fittings and specials, complete in place. Polyurethane and fusion bond epoxy lining and coating material shall be furnished only by an OWNER-approved manufacturer.

1.2 RELATED SECTIONS

- A. The WORK of the following Sections applies to the WORK of this Section. Other Sections of the Specifications, not referenced below, shall also apply to the extent required for proper performance of this WORK.

- 1. Section 02140 Dewatering
- 2. Section 02200 Earthwork
- 3. Section 02600 Pipeline Construction
- 3. Section 02666 Water Pipeline Testing and Disinfection
- 5. Section 05500 Miscellaneous Metalwork
- 6. Section 09800 Protective Coating
- 7. Section 09810 Polyethylene Tape Coating
- 8. Section 15000 Piping Components
- 9. Section 15025 Cathodic Protection System

1.3 STANDARD SPECIFICATIONS

- A. Except as otherwise indicated in this Section of the Specifications, the CONTRACTOR shall comply with the Standard Specifications for Public Works Construction (SSPWC), as specified in Section 01090 - REFERENCE STANDARDS.

1.4 SPECIFICATIONS AND STANDARDS

- A. Except as otherwise indicated, the current editions of the following apply to the WORK of this Section:

- 1. ASTM A 36 Structural Steel
- 2. ASTM A 139 Electric Fusion (Arc)-Welded Steel Pipe
- 3. ASTM A 234 Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

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| 4. | ASTM A 283 | Low and Intermediate Tensile Strength Carbon Steel Plate |
| 5. | ASTM A 370 | Mechanical Testing of Steel Products |
| 6. | ASTM A 570 | Hot Rolled Carbon Steel Sheet and Strip, Structural Quality |
| 7. | ASTM A 572 | High-Strength Low-Alloy Columbium, Vanadium Steels of Structural Quality |
| 8. | ASTM C 150 | Portland Cement |
| 9. | ASTM D 16 | Definition of Terms Relating to Paint, Varnish, Lacquer, and Related Products |
| 10. | ASTM D 471 | Test Method for Rubber Property - Effect of Liquids |
| 11. | ASTM D 2240 | Test Method for Rubber Property - Durometer Hardness |
| 12. | ASTM D 4060 | Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser |
| 13. | ASTM D 4541 | Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers |
| 14. | ASTM E 96 | Test Methods for Water Vapor Transmission of Materials |
| 15. | ASTM E 165 | Methods for Liquid Penetrant Inspection |
| 16. | ANSI/AWWA C200 | Steel Water Pipe 6 In. and Larger |
| 17. | ANSI/AWWA C203 | Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied |
| 18. | ANSI/AWWA C205 | Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. and Larger - Shop Applied |
| 19. | ANSI/AWWA C206 | Field Welding of Steel Water Pipe |
| 20. | ANSI/AWWA C208 | Dimensions for Fabricated Steel Water Pipe Fittings |
| 21. | ANSI/AWWA C209 | Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines |
| 22. | ANSI/AWWA C602 | Cement-Mortar Lining of Water Pipelines 4-In and Larger - in Place |
| 23. | ANSI/AWS D1-1 | Structural Welding Code: Steel |
| 24. | AWWA M-11 | Steel Water Pipe - A Guide for Design and Installation. |

1.5 SHOP DRAWINGS AND SAMPLES

A. The following shall be submitted in compliance with Section 01300:

1. Shop drawings and catalog information on pipe and fittings.
2. Pipe and fitting wall construction details which indicate the type and thickness of the cylinder; the position, type, size, and area of reinforcement; manufacturing tolerances; and all other pertinent information required for the manufacture of the product. Joint details shall be submitted in all cases [including those where deep bell or butt strap joints are required for control of temperature stresses.]
3. Fittings and specials details such as elbows, reducers, wyes, tees, crosses, outlets, connections, test bulkheads, and nozzles or other specials where shown which indicate amount and position of all reinforcement. All fittings and specials shall be properly reinforced to withstand the internal pressure, both circumferential and longitudinal, and the external loading conditions as indicated in the Contract Documents.
4. Design calculations [including a complete stress analysis] of each critical section of pipe wall, girth joints, and specials - all sufficient to ascertain conformance of pipe and fittings with the Specifications.
5. Material lists and steel reinforcement schedules which include and describe all materials to be utilized.
6. Full and complete information regarding location, type, size, and extent of all welds shall be shown on the shop drawings. The shop drawings shall distinguish between shop and field welds. Shop drawings shall indicate by welding symbols or sketches the details of the welded joints, and the preparation of parent metal required to make them. Joints or groups of joints in which welding sequence or technique are especially important shall be carefully controlled to minimize shrinkage stresses and distortion.
7. Shop and field welding procedures and Welders' Qualification Certification.

1.6 OWNER'S MANUAL

A. The following shall be included in the OWNER'S MANUAL in compliance with Section 01300:

1. Certifications: The CONTRACTOR shall furnish a certification stating that all pipe, special fittings, and other products or materials furnished under this Section of the Specifications comply with ANSI/AWWA C200, C203 and C205. Additionally, the CONTRACTOR shall furnish certified reports of the following tests:
 - a. Physical and chemical properties of all steel.
 - b. Hydrostatic test reports.
 - c. Results of production weld tests.

B. All expenses incurred in making samples for certification of tests shall be borne by the CONTRACTOR.

FACTORY INSPECTION, TESTS AND WELDING REQUIREMENTS

- C. The CONTRACTOR shall be responsible for all costs associated with inspection and testing of materials, products, or equipment at the place of manufacture. This shall include costs for travel, meals, lodging, and car rental for [two] OWNER-designated inspectors for [] days required to complete such inspections or observations exclusive of travel days, if the place of manufacture, fabrication and factory testing is more than fifty (50) miles outside the geographical limit of the City. The CONTRACTOR shall not be responsible for salary or salary-related costs of the inspectors. The CONTRACTOR shall comply with the requirements of Section 01400.
- B. **Inspection:** All pipe shall be subject to inspection at the place of manufacture and place of coating application in accordance with the provisions of ANSI/AWWA C200, C203 and C205 as supplemented by the requirements herein. The CONTRACTOR shall notify the CONSTRUCTION MANAGER in writing of the manufacturing starting date not less than 14 calendar days prior to the start of any phase of the pipe manufacture.
- C. **Tests:** Except as modified herein, all materials used in the manufacture of the pipe shall be tested in accordance with the requirements of ANSI/AWWA C200, C203 and C205 as applicable.
1. Shop testing of steel pipe:
 - a. After the joint configuration is completed and prior to lining with cement-mortar, each length of pipe of each diameter and pressure class shall be shop-tested and certified to a pressure of at least 80 percent of the yield strength of the pipe steel.
 - b. Production weld tests shall be conducted in compliance with ANSI/AWWA C200. In addition to the frequency of tests required in ANSI/AWWA C200, weld tests shall be conducted on each 5,000 feet of production welds and at any other times there is a change in the welder, the welding procedure, or the welding equipment.
 2. Shop testing of steel plate specials:
 - a. Upon completion of the welding, but prior to lining and coating, each steel plate special shall be bulkheaded and tested under a hydrostatic pressure of 1-1/2 times the design pressure; provided, that if straight pipe used in fabricating the specials has been previously tested and meets the requirements of the applicable piping Section, no further hydrostatic testing will be required; or provided, that all other welded seams are tested by the liquid penetrant inspection procedure conforming to ASTM E 165, under Method "B" and "Leak Testing" or where applicable by the soap and compressed air method at an air pressure of 25 psi. Any pin holes or porous welds which may be revealed by the test shall be chipped out and rewelded and the pipe or fitting retested.
 - b. No outside coating shall be applied over a seam prior to testing; however, mortar lining may be applied over a seam prior to hydrostatic testing, but under such conditions said pressure test shall be held on the pipe or fitting for a period of not less than 30 minutes.
- D. The CONTRACTOR shall perform said material tests at no additional cost to the OWNER. The CONSTRUCTION MANAGER will witness all testing conducted by the CONTRACTOR; provided, that the CONTRACTOR'S schedule is not delayed for the convenience of the CONSTRUCTION MANAGER.

- E. In addition to those tests specifically required, the CONSTRUCTION MANAGER may request additional samples of any material including mixed concrete and lining and coating samples for testing by the OWNER. The additional samples shall be furnished at no additional cost to the OWNER.
 - F. **Welding Requirements:** All welding procedures used to fabricate pipe shall be prequalified under the provisions of ANSI/AWS D1.1. Welding procedures shall be required for, but not necessarily limited to, longitudinal and girth or spiral welds for pipe cylinders, spigot and bell ring attachments, reinforcing plates and ring flange welds, and plates for lug connections.
 - G. **Welder Qualifications:** All welding shall be done by skilled welders, welding operators, and tackers who have had adequate experience in the methods and materials to be used. Welders shall be qualified under the provisions of ANSI/AWS D1.1 by an independent local, approved testing agency not more than 6 months prior to commencing work on the pipeline. Machines and electrodes similar to those used in the WORK shall be used in qualification tests. The CONTRACTOR shall furnish all material and bear the expense of qualifying welders.
- 1.7 PRODUCT DELIVERY, STORAGE AND HANDLING.
- A. All pipe, fittings, etc., shall be carefully handled and protected against damage to lining and coating/interior and exterior surfaces, impact shocks, and free fall. The pipe and specials shall be handled by use of wide slings, padded cradles, or other devices designed and constructed to prevent damage to the pipe coating/exterior. The use of chains, hooks, or other equipment which might injure the pipe coating/exterior will not be permitted. Pipe shall not be placed directly on rough ground but shall be supported in a manner which will protect the pipe against injury whenever stored at the trench site or elsewhere.

PART 2 -- PRODUCTS

2.1 GENERAL

- A. Mortar lined and enamel coated steel pipe shall conform to SSPWC subsection 207-10, subject to the supplementary requirements indicated herein. Mortar lined steel pipe shall conform to ANSI/AWWA C200, C203, C205 and C208, subject to the following supplemental requirements.
- B. Specials are defined as fittings, closure pieces, bends, reducers, wyes, tees, crosses, outlets, manifolds, and other steel plate specials wherever located, and all piping above ground or in structures.
- C. The pipe shall be of the diameter shown, shall be furnished complete with rubber gaskets or welded joints as indicated in the Contract Documents, and all specials and bends shall be provided as required under the Contract Documents. For pipe 14 inches in diameter and larger, the inside diameter after lining shall not be less than the nominal diameter indicated. Pipe smaller than 14 inches in diameter may be furnished in standard outside diameters.
- D. **Markings:** The CONTRACTOR shall legibly mark all pipes and specials in accordance with the laying schedule and marking diagram. Each pipe shall be numbered in sequence and said number shall appear on the laying schedule and marking diagram in its proper location for installation. All

special pipe sections and fittings shall be marked at each end indicating the top. The word "top" shall be painted or marked on the outside top spigot end of each pipe section.

- E. Stockpiled pipe and specials shall be suitably supported on sand or earth berms free of rock exceeding 3 inches in diameter. The pipe shall not be rolled and shall be secured to prevent accidental rolling.
- F. The CONTRACTOR shall be fully liable for the cost of replacement or repair of pipe and specials which are damaged.
- G. **Strutting:** Adequate strutting shall be provided on all specials, fittings, and straight pipe so as to avoid damage to the pipe and fittings during handling, storage, hauling, and installation. In addition, the following requirements shall apply:
 - 1. The strutting shall be placed as soon as practicable after the mortar lining has been applied and shall remain in place while the pipe is loaded, transported, unloaded, installed, and backfilled at the jobsite.
 - 2. The strutting materials, size and spacing shall be adequate to support the earth backfill plus any greater loads which may be imposed by the backfilling and compaction equipment.
 - 3. Any pipe damaged during handling, hauling, storage, or installation due to improper strutting shall be repaired or replaced.
 - 4. The details of the strutting assembly shall be submitted for review by the CONSTRUCTION MANAGER prior to the start of pipe manufacture.
- H. **Laying Lengths:** Maximum pipe laying lengths shall be 40 ft with shorter lengths provided as required.
- I. **Offset Tolerances:** For pipe wall thicknesses of 3/8-inch or less, the maximum radial offset (misalignment) for submerged arc and gas metal arc welded pipe shall be 0.1875 times the pipe wall thickness or 1/16-inch, whichever is larger. For pipe wall thicknesses of greater than 3/8-inch, the maximum radial offset shall be 0.1875 times the wall thickness or 5/32-inch, whichever is smaller.
- J. **Lining:** The pipe lining shall have smooth dense interior surfaces and shall be free from fractures, excessive interior surface crazing and roughness.
- K. **Closures and Correction Pieces:** Closures and correction pieces shall be provided as required so that closures may be made due to different headings in the pipe laying operation and so that correction may be made to adjust the pipe laying to conform to pipe stationing shown on the Drawings. The locations of correction pieces and closure assemblies are shown on the Drawings. Any change in location or number of said items shall be submitted for review by the CONSTRUCTION MANAGER.

2.2 PIPE DESIGN CRITERIA

A. General:

1. The pipe shall be steel pipe with rubber gasketed or field welded joints as indicated.
2. The pipe shall be designed, manufactured, tested, inspected, and marked according to applicable requirements of ANSI/AWWA C 200 except as hereinafter modified.
3. The pipe shall be of the diameter indicated and be suitable for the indicated pressure. The minimum steel cylinder thickness for each pipe size shall be as indicated.
4. Steel cylinder thickness for internal pressure shall be determined in accordance with the more stringent of the criteria specified in subparagraphs B. and C. below.

B. Cylinder Thickness for Internal Pressure: For resistance to internal pressure, the thickness of the steel cylinder shall not be less than the greater of that determined by the following 2 formulas:

$$(1) \quad T = \frac{P_w D/2}{Y/S_w}$$

$$(2) \quad T = \frac{P_t D/2}{Y/S_t}$$

| | | | |
|--------|----------------|---|---|
| Where: | T | = | Steel Cylinder thickness in inches |
| | D | = | Outside diameter of steel cylinder in inches |
| | P _w | = | Design working pressure in psi |
| | P _t | = | Design transient pressure in psi |
| | Y | = | Specified minimum yield point of steel in psi |
| | S _w | = | Safety factor of 2.0 at design working pressure |
| | S _t | = | Safety factor of 1.5 at design transient pressure |

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NTS: The effect of an S_t of 1.5 (CWP design standard) means that the hoop stress for transient pressure can be allowed to rise by 33 percent above the stress for working pressure ($y/1.5 \div y/2 = 1.33$). This differs from AWWA M11 which allows the hoop stress under transient loads to rise by 50 percent ($0.75y \div 0.50y = 1.50$).

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- C. Unless otherwise indicated, P_w shall be assumed to equal the indicated pipe pressure class and P_t shall be assumed to equal 1.33 P_w. In no case shall the design stress (Y/S_w, using a safety factor of 2.0 to yield strength) exceed 21,000 psi at design working pressure, P_w, nor shall the design stress (Y/S_t, using a safety factor of 1.5 to yield strength) exceed 28,000 psi at design transient pressure, P_t, nor shall the steel shell thickness be less than [No. 10 gauge (0.135 in.)] or the nominal pipe diameter divided by 240, whichever is greater, as shown in the following table:

| Nominal Pipe Diameter (in) | Minimum Cylinder Thickness (in) |
|-------------------------------|------------------------------------|
| 6 | 0.135 |
| 12 | 0.135 |
| 18 | 0.135 |
| 24 | 0.135 |
| 30 | 0.135 |
| 36 | 0.15 |
| 42 | 0.175 |
| 48 | 0.20 |
| 54 | 0.225 |
| 60 | 0.25 |
| 66 | 0.275 |
| 72 | 0.30 |
| 78 | 0.325 |
| 84 | 0.35 |
| 90 | 0.375 |
| 96 | 0.40 |
| 102 | 0.425 |
| 108 | 0.45 |
| 114 | 0.475 |
| 120 | 0.50 |

- D. **Cylinder Thickness for External Load:** Upon determination of cylinder thickness, for internal pressure, deflection of the pipe shall be checked by the following formula:

$$\text{Defl}_x = \frac{DKWr^3}{EI + 0.0614 E'r^3}$$

Where: Defl_x = Vertical deflection of pipe in inches, not to exceed 0.0225 times the nominal diameter.

D = Deflection lag factor [1.25]

K = Bedding constant [0.1]

W = Vertical load on pipe, lb/in (*See Note 1*)

r = Mean radius of pipe shell, inches

EI = Pipe wall stiffness, lb/in (*See Note 2*)

E' = Modulus of soil reaction, lb/in² [700 for 90 percent Standard Proctor; 1500 for 95 percent Standard Proctor; 2500 for 100 percent Standard Proctor, i.e., cement, crushed rock]

Note 1: For depths of cover of 10 feet or greater, the earth load shall be computed assuming the trench/embankment condition as applicable. For depths of cover less than 10 feet, HS-20 live load shall also be considered. For depths of cover of 3 feet or less, HS-20 live load plus impact load shall also be considered. The determination of live load and impact factors shall be as recommended by AASHTO in "Standard Specifications for Highway Bridges."

Note 2: Based on the sum of the pipe wall stiffnesses, EI, of the lining, coating, and steel cylinder, assuming that it acts as a three-part laminar ring which considers no bond between the steel cylinder and the applied lining and coating. The term "pipe wall stiffness" as used herein is defined as EI, where "E" is the modulus of elasticity (E=30,000,000 psi for steel and E=4,000,000 psi for mortar) and "I" is the transverse moment of inertia per unit length of pipe wall, the factors in the foregoing expression to be dimensionally compatible.

Trench Condition:

$$W_d = C_d w B_d^2$$

Where: W_d = Earth Load in pounds per linear foot
 C_d = Calculation Coefficient
 Ku' = [0.13]
 w = [120] lb/ft³
 B_d = Trench width at top of pipe, feet

Positive Projecting Embankment Condition:

$$W_c = C_c w B_c^2$$

Where: W_c = Earth Load in pounds per linear foot
 C_c = Calculation Coefficient (based on r_{sd} of 0.25)
 Ku = [0.19]
 w = [120] lb/ft³
 B_c = Outside diameter of pipe, feet
 r_{sd} = Settlement ratio
 p = Projection ratio

- E. If the calculated deflection, $Defl_p$, exceeds 0.0225 times the nominal diameter, the composite pipe section shall be thickened or the quality of pipe zone backfill shall be improved to achieve a higher soil modulus (e.g., lean concrete, soil/sand cement, crushed rock).

2.3 DESIGN OF SPECIALS

- A. Except as otherwise provided herein, materials, fabrication and shop testing of straight pipe shall conform to the requirements of ANSI/AWWA C200. Dimensions for fittings shall conform to ANSI/AWWA C208. The minimum thickness of plate for pipe from which specials are to be fabricated shall be the greater of that determined by the following 2 formulas:

$$(1) \quad T = \frac{P_w D/2}{Y/S_w}$$

$$(2) \quad T = \frac{P_i D/2}{Y/S_t}$$

| | | | |
|--------|----------------|---|---|
| Where: | T | = | Steel cylinder thickness in inches |
| | D | = | Outside diameter of steel cylinder in inches |
| | P _w | = | Design working pressure in psi |
| | P _t | = | Design transient pressure in psi |
| | Y | = | Specified minimum yield point of steel in psi |
| | S _w | = | Safety factor of 2.5 at design working pressure |
| | S _t | = | Safety factor of 1.875 at design transient pressure |

- B. In no case shall the design stress at design working pressure (Y/S_w) for enamel or tape coated steel pipe exceed 21,000 psi or 28,000 psi at design transient pressure (Y/S_t), nor shall plate thickness be less than the thickness of adjacent mainline pipe or the following:

| Nominal Pipe Diameter (in) | Pipe Manifolds | Elbows |
|-------------------------------|---|-------------------|
| | Piping Above Ground Piping in Structures | Bends Reducers |
| 24 and under | 3/16-in | 10-ga |
| 25 to 48 | 1/4-in | 1/4-in |
| over 48 | 5/16-in | 5/16-in |

- C. Pipe installed on saddle supports shall be designed to limit the longitudinal bending stress to a maximum of 10,000 psi. Design shall be in accordance with the provisions of Chapter 7 of AWWA M-11.

2.4 MATERIALS

- A. **Cement:** Cement for mortar shall conform to the requirements of ANSI/AWWA C205; provided, that cement for mortar lining shall be Type II. Fly ash or pozzolan shall not be used as a cement replacement.
- B. **Steel for Cylinders and Fittings:** Pipe manufactured under ANSI/AWWA C200 shall be fabricated from sheets conforming to the requirements of ASTM A 570, Grades 30, 33, 36 or 40, or from plates conforming to the requirements of ASTM A 36, A 283, Grades C or D, or A 572, Grade 42, or coil conforming to the requirements of ASTM A 139, Grades B or C. All longitudinal and girth seams, whether straight or spiral, shall be butt welded using an approved electric-fusion-weld process.
- C. All steel used for the fabrication of pipe shall have a maximum carbon content of 0.25 percent, a maximum sulfur content of 0.015 percent, and shall have a minimum elongation of 22 percent in a 2-inch gauge length.
- D. Steel exceeding 1/2-inch in thickness used in fabricating pipe shall be tested for notch toughness for each heat using the Charpy V-Notch test in accordance with ASTM A 370. The steel shall withstand a minimum impact of 25 ft lb at a temperature of 30 degrees F.
- E. Steel shall be fine-grained, fully killed and manufactured by the continuous casting process.

2.5 JOINT DESIGN

- A. The standard field joint for steel pipe shall be either a single-welded lap joint or a rubber-gasketed joint for all pipe sizes up to and including [54] [60] inch diameter and shall be a single-welded lap joint for pipe sizes above [54] [60] inch diameter. Mechanically coupled, or flanged joints shall be required where shown. Butt-strap joints shall be used only where required for closures or where shown. The joints furnished shall have the same or higher pressure rating as the abutting pipe.

- B. **Lap Joints:** Lap joints prepared for field welding shall be in accordance with ANSI/AWWA C200. The method used to form, shape and size bell ends shall be such that the physical properties of the steel are not substantially altered. Unless otherwise approved by the CONSTRUCTION MANAGER, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape. No process will be permitted in which the bell is formed by rolling. Faying surfaces of the bell and spigot shall be essentially parallel, but in no case shall the bell slope vary more than 2 degrees from the longitudinal axis of the pipe.
- C. **Bell-and-Spigot Joints:** For bell-and-spigot ends with rubber gaskets, the clearance between the bells and spigots shall be such that when combined with the gasket groove configuration and the gasket itself, will provide watertight joints under all operating conditions when properly installed. The CONTRACTOR shall require the pipe manufacturer to submit details complete with significant dimensions and tolerances and also to submit performance data indicating that the proposed joint has performed satisfactorily under similar conditions. In the absence of a history of field performance, the results of a test program shall be submitted. Unless otherwise approved by the CONSTRUCTION MANAGER, bell ends shall be formed by an expanding press or by being moved axially over a die in such a manner as to stretch the steel plate beyond its elastic limit to form a truly round bell of suitable diameter and shape. No process will be permitted in which the bell is formed by rolling. Further, unless otherwise approved by the CONSTRUCTION MANAGER, spigot ends with rolled gasket grooves shall be non-destructively tested by the dye penetrant or magnetic particle method for the full circumference, especially at the weld seam area. The actual yield strength of the steel used in the spigot rolling operation (i.e. yield strength values in mill certifications and subsequent destructive test results) shall be limited to 50,000 psi.
- D. Shop-applied interior linings and exterior coatings shall be held back from the ends of the pipe as indicated or as otherwise acceptable to the CONSTRUCTION MANAGER.
- E. **Restrained Joints:** Where indicated, restrained joints shall be field-welded joints. Designs shall include considerations of stresses induced in the steel cylinder, the joint rings, and any field welds, caused by thrust at bulkheads, bends, reducers, and line valves resulting from the design working pressure. For field welded joints, design stresses shall not exceed 50 percent of the indicated minimum yield strength of the grade of steel utilized, or 16,500 psi, whichever is less, for the part being examined when longitudinal thrust is assumed to be uniformly distributed around the circumference of the joint. At the CONTRACTOR's option, the steel cylinder area may be progressively reduced from the point of maximum thrust to the end of the restrained length. All joints to be field welded for thrust restraint shall have the joint rings attached to the cylinder with double fillet welds.

2.6 CEMENT-MORTAR LINING OF PIPE

- A. **Cement-Mortar Lining for Shop Application:** Except as otherwise required, interior surfaces of all steel pipe, fittings, and specials shall be cleaned and lined in the shop with cement-mortar lining applied centrifugally in conformity with ANSI/AWWA C205. During the lining operation and thereafter, the pipe shall be maintained in a round condition by suitable bracing or strutting. The lining machines shall be of a type that has been used successfully for similar work. Every precaution shall be taken to prevent damage to the lining. If lining is damaged or found faulty at delivery site, the damaged or unsatisfactory portions shall be replaced with lining conforming to these Specifications at no additional cost to the OWNER.
- B. The minimum lining thickness shall be as follows, with a tolerance of plus or minus 25 percent:

| Nominal Pipe Diameter (in) | Lining Thickness (in) |
|-------------------------------|--------------------------|
| 4-12 | 5/16 |
| 13-16 | 3/8 |
| 17-24 | 1/2 |
| over 24 | 3/4 |

- C. The pipe shall be left bare where field joints occur as indicated. Ends of the linings shall be left square and uniform. Feathered or uneven edges will not be permitted.
- D. Defective linings, as determined by the CONSTRUCTION MANAGER, shall be removed from the pipe wall and shall be replaced to the full thickness required. Defective linings shall be cut back to a square shoulder in order to avoid feather edged joints.
- E. The progress of the application of mortar lining shall be regulated in order that all hand work, including the repair of defective areas is cured in accordance with the provisions of ANSI/AWWA C205. Cement-mortar for patching shall be the same materials as the mortar used for machine lining, except that a finer grading of sand and mortar richer in cement shall be used when field inspection indicates that such mix will improve the finished lining of the pipe.
- [F. **Cement-Mortar Lining for Field Application:** The materials and design of in-place cement-mortar lining shall be in accordance with ANSI/AWWA C602 and the following supplementary requirements:
 - 1. Portland cement shall conform to Type II, ASTM C 150.
 - 2. Pozzolan material shall not be used in the mortar mix.
 - 3. Admixtures shall contain no calcium chloride.
 - 4. The minimum lining thickness shall be as indicated for shop-applied cement-mortar lining and the finished inside diameter after lining shall be as shown.]
- G. **Protection of Pipe Lining and Interior:** For all pipe and fittings with plant-applied or field applied cement-mortar linings, the CONTRACTOR shall provide a polyethylene or other suitable bulkhead on the ends of the pipe and on all special openings to prevent drying out of the lining. All bulkheads shall be substantial enough to remain intact during shipping and storage until the pipe is installed.

2.7 EXTERIOR COATING OF PIPE

- A. **Exterior Coating of Exposed Piping:** The exterior surfaces of pipe which will be exposed to the atmosphere inside structures or above ground shall be thoroughly cleaned and then given a shop coat of rust-inhibitive primer and then finish coated in conformance to the requirements of Section 09800.
- B. **Coal-Tar Enamel Coating:** Coal-tar protective coating shall be a multi-layer coal-tar enamel fibrous glass mat and mineral glass felt wrap conforming to ANSI/AWWA C203 except as indicated below:
 - 1. Coating Conditions

- a. Pipe surfaces shall be prepared by solvent cleaning (SSPC-SP1) followed by blasting to at least Commercial Blast Cleaning (SSPC-SP6) conditions.
 - b. Pipe temperatures shall be at least 85 degrees F.
2. Primer shall be type B.
3. Coal-Tar Enamel: Specially processed coat-tar pitch combined with inert filler, having no asphalt or petroleum of natural origin, of Type 1, applied hot.
4. Glass Fiber Wrap: Non-woven, either reinforced or non-reinforced, glass fiber mat uniformly impregnated with material compatible with coat-tar enamel.
5. Coal-Tar Enamel: Second coat matching the first.
6. Glass fiber or mineral felt outer wrap.
7. Whitewashing, latex painting, or kraft paper.
8. Coating Thickness: Primer plus coat-tar enamel shall be 3/32 inch thick, plus or minus 1/32 inch.
9. Continuity Testing: The entire coated surface of the pipe shall be electrically tested for continuity. Inspection voltage shall be calculated as:

$$V = 1250[T]^{1/2}$$

Where: V = Test voltage, volts

T = Total coating system thickness, mils

- C. **Prefabricated Tape Coating:** Tape coating shall be in accordance with Section 09810. Holiday testing shall be calculated from:

$$V = 1250[T]^{1/2}$$

Where: V = Test voltage, volts

T = Total tape coating system thickness, mils

2.8 FABRICATION OF SPECIALS

- A. **General:** Specials and fittings shall conform to dimensions stipulated in ANSI/AWWA C208. Reinforcement for wyes, tees, outlets, and nozzles shall be designed in accordance with AWWA Manual M-11. Reinforcement shall be designed for the pressure indicated and shall be in accordance with the Standard Details. Specials and fittings shall be equal in pressure design strength and shall have the same lining and coating as the adjoining pipe. Unless otherwise shown, the minimum radius of elbows shall be 2.5 times the pipe diameter and the maximum miter angle on each section of the elbow shall not exceed 11-1/4 degrees.
- B. Specials and fittings that cannot be mechanically lined shall be lined by hand-application, using the same materials as are used for the pipe and in accordance with the applicable ANSI/AWWA C 602 Standards. Lining applied in this manner shall provide protection equal to that indicated for the pipe. Fittings may be fabricated from pipe that has been mechanically lined. Areas of lining that have

been damaged by such fabrication shall be repaired by hand-applications in accordance with applicable ANSI/AWWA C 602 Standards.

- C. **Outlets, Tees, Wyes, and Crosses:** Outlets 12-inch and smaller may be fabricated from Schedule 30 or heavier steel pipe in the standard outside diameters, i.e., 12¾-inch, 10¾-inch, 8-inch, 6-inch, and 4½-inch. Access manholes shall be located as indicated.
 - D. The design of outlet reinforcement shall be in accordance with the procedures given in Chapter 13 of AWWA Manual M-11, except that the design pressure, P, used in the M-11 procedure shall equal the greater of 1.25 P_w or 0.9375 P_i. Unless otherwise indicated, outlets 2 inches in diameter and smaller need not be reinforced.
 - 1. In lieu of saddle or wrapper reinforcement as required by the design procedure in Manual M-11, pipe or specials with outlets may be fabricated in their entirety of steel plate having a thickness equal to the sum of the pipe wall plus the required reinforcement.
 - 2. All threaded outlets shall be forged steel suitable for 3000 psi service.
 - E. Where required by the M-11 design procedure, crotch plate reinforcement shall be furnished.
 - F. **Steel Welding Fittings:** Steel welding fittings shall conform to ASTM A 234.
 - G. **Ends for Mechanical-Type Couplings:** Except as otherwise required, where mechanical-type couplings are indicated, the ends of pipe shall be banded with Type C collared ends using double fillet welds. Where pipe 12-inch and smaller is furnished in standard schedule thicknesses, and where the wall thickness equals or exceeds the coupling manufacturer's minimum wall thickness, the pipe ends may be grooved.
 - H. **Lining:** All requirements pertaining to thickness, application and curing of lining indicated for straight pipe shall apply to specials, with the following proviso. If the special cannot be lined centrifugally, it shall be lined by hand. In such case, the lining shall be reinforced with 2-in by 4-in No. 12 welded wire fabric positioned approximately in the center of the lining. The wires spaced 2-in on centers shall extend circumferentially around the pipe with the fabric securely fastened to the pipe. Splices shall be lapped 4 inches and the free ends tied or looped to assure continuity.
 - I. **Coating of Fittings and Specials:** Fittings and specials shall be coated in accordance with Section 09810.
 - 1. Unless otherwise indicated, the coating on the buried portion of a pipe passing through the wall of a structure shall extend to the center of the wall or the wall flange, if one is indicated.
 - 2. Pipe above ground or in structures shall be field painted as required in Section 09800.
 - J. **Marking:** A mark indicating the true vertical axis of the special shall be placed on the top and bottom of the special.
- 2.9 PIPE APPURTENANCES
- A. Pipe appurtenances shall be in accordance with the requirements of Section 15000.
- 2.10 BURIED PIPE APPURTENANCES

- A. Buried appurtenances for coal tar enamel-coated pipe shall be coated with cold-applied tape in accordance with AWWA C209, Type II.

2.11 FUSION-BONDED EPOXY COATING AND LINING

- A. **General:** Except as described below, the material system for the exterior and interior of steel pipe and fittings installed underground or underwater shall be in accordance with ANSI/AWWA C213.
- B. **Minimum Pipe Diameter:** The minimum pipe diameter for application of an internal lining shall be 8 inches for welded joint pipe, and 4 inches for gasketed joint pipe.
- C. **Maximum Temperature:** This material system shall be able to withstand a maximum service temperature of 190° F.
- D. **Thickness:** The powder shall be applied to the preheated pipe at a uniform cured thickness. The minimum nominal uniform cured thickness of the applied material shall be as follows:
 - 1. Interior, 16 mils minimum
 - 2. Exterior, 14 mils minimum
 - 3. Maximum thickness shall be determined by the applicator based on the roughness of the pipe so as to obtain a holiday free product. Lining and coating thickness for pipe joints shall be compatible with dimensional tolerances.
- E. **Field-Welded Joints:** The repair of field-welds shall be per Section 3.5 of ANSI/AWWA C213, EXCEPT that Subsection 3.5.3 shall not be used for the internal repair. After joint repair the joint shall be tested for continuity per Subsection G.2 below.
- F. **Blast Cleaning:** The pipe surfaces to be covered in the plant shall be blast-cleaned with steel grit to achieve a near white surface conforming to SSPC-SP10 or NACE TM-01-70 grade NACE No. 1.
- G. **Continuity Tests:**
 - 1. Interior of pipe shall be electrically inspected for continuity at 2100 volts. At the option of the CONSTRUCTION MANAGER, if the number of holidays exceeds one per 3 linear feet of pipe 20 inches O.D. or smaller, or one per 2 linear feet of pipe over 20 inches O.D., the pipe shall be reprocessed. If not reprocessed, all defects disclosed by the holiday detector shall be repaired in the shop according to Subsection 3.4 - Coating Repair of the ANSI/AWWA C213 specifications.
 - 2. Exterior of pipe shall be electrically inspected for continuity at 1965 volts. At the option of the CONSTRUCTION MANAGER, if the number of holidays exceeds one per 3 linear feet of pipe length for pipe smaller than 14 inches O.D., or one per 25 square feet of surface area for pipe 14 inches in O.D. and larger, the pipe shall be reprocessed. If not reprocessed, all defects disclosed by the holiday detector shall be repaired in the shop according to Subsection 3.4 - Coating Repair of the ANSI/AWWA C213 specifications.
- H. **Coating Repair and Field Touch-Up:** If gasketed joint pipe is used, exothermic weld connections for the installation of bond cables across joints of the pipeline for cathodic protection shall be repaired and touched-up with 3M-312 material or equal.

NTS: The DESIGN CONSULTANT shall prepare a list of candidate manufacturers for the proposed coating/lining material from which list the OWNER will select and approve the fusion bond epoxy manufacturer for the project.

I. Fusion Bond Epoxy Manufacturers:

1. []
2. []
3. [or equal]

J. Qualifications, Approval, and Documentation of Fusion Bond Epoxy Manufacturers

1. **Qualifications:** The fusion bond epoxy manufacturer shall have a record of at least one application of the proposed coating/lining material on a successfully performing steel pipe installation of comparable size and complexity constructed in the recent past.
2. Approval
 - a. Bidders shall submit the name and documented qualifications of the manufacturer proposed for the fusion bond epoxy material. The OWNER will review and approve the proposed selection.
 - b. Documentation to be submitted CONTRACTOR
 - (1) Documentation of at least one steel pipe project constructed in the recent past and successfully performing under similar service conditions.
 - (2) The name, telephone number, and address of the owner and completion date and location for the project listed above.
 - (3) The name, telephone number, and address of the firm which applied the fusion bond epoxy in the project listed above.
 - (4) Descriptive literature, including Material Safety Data Sheet, for the proposed material.

2.12 POLYURETHANE COATING AND LINING

- A. **Material:** Polyurethane material shall be a 1 to 1 polyol resin to isocyanate resin 2-component mixture, of Type V according to ASTM D 16.
- B. **Performance:** Coating and lining shall have the following properties:
 1. Impact Resistance no less than 80 inch pounds when tested according to ASTM G14 for 40-mil thickness
 2. Adhesion no less than 2,000 psi when tested according to ASTM D4541

- | | | |
|----|---------------------|---|
| 3. | Hardness | 65 (plus or minus 5), Shore D, at 70 degrees F, when tested according to ASTM D 2240. |
| 4. | Abrasion Resistance | less than 100 mg weight loss per 1,000 revolutions of a CS-17 wheel when tested according to ASTM D 4060 |
| 5. | Chemical Resistance | less than 5 percent weight change after 90 days tested according to ASTM D 543 (10% H ₂ SO ₄ , 10% HCL, 30%NaOH, H ₂ S, raw sewage) |
| 6. | Permeability | less than 0.0005 perm inches when tested according to ASTM E 96 |
| 7. | Dielectric Strength | no less than 200 volts per mil of coating |
| 8. | Coal Tar Content | zero percent |
| 9. | Fillers | less than 30 percent |

C. Application Conditions

1. Pipe surfaces shall be prepared by solvent washing (SSPC-SP1) followed by near white blast (SSPC-SP10) with an angular profile of at least 2.5 microns.
2. Pipe temperatures shall be at least 5 degrees F warmer than the dewpoint in the area of the application equipment. Pipe shall be warmed if necessary.
3. Material components shall be stored at temperatures warmer than 50 degrees F and shall not be stored longer than 6 months. Older components shall not be used.

D. Thicknesses: Material shall have the following minimum nominal thicknesses:

- | | | |
|----|------------------------------------|---|
| 1. | Pipe Interior | 40 mils |
| 2. | Pipe Exterior | 25 mils |
| 3. | Sealing Areas on Bells and Spigots | 8 mils. Thicker material which does not compromise joint tightness may be accepted. |
| 4. | Factory Testing | |
- a. The entire surface coated and lined with polyurethane shall be tested at 200 volts per mil for holidays after curing. Every holiday shall be repaired as indicated below.
 - b. Entire pipe surface shall be inspected visually. Pipe with sharp protuberances or significant sags, dimples, or curtains will not be accepted.
 - c. The CONSTRUCTION MANAGER will select one section of pipe from each lot of 20 sections for thickness testing by the CONTRACTOR. Tests shall be made by a Type 1 magnetic thickness gage. The CONSTRUCTION MANAGER will designate locations for spot measurements taken at the points of an equilateral triangle 3 inches on a side: the triangles shall be located at both ends, in the middle, and at the midpoints of each half of the pipe, plus 5 randomly-selected individual points.
 - (1) No single spot measurement shall be less than 75 percent of the indicated minimum nominal thickness.

- (2) The average of three spot measurements from any triangle shall not be less than 80 percent of the indicated minimum nominal thickness.
- (3) The average of all spot measurements on a pipe shall not be less than the indicated minimum nominal thickness.

- d. Sections of pipe selected by the CONSTRUCTION MANAGER for thickness testing will also be tested by the CONSTRUCTION MANAGER for delamination by scoring and prying with a pocket knife.
- e. If the tested pipe complies with the thickness criteria above and shows no sign of delamination by knife test, all pipe in the lot of 20 will be considered as complying with requirements and the tested pipe may be repaired for installation. If the tested pipe fails either test, five additional sections from the same lot will be tested in similar fashion, and if all five pass all tests, then the lot, except for the pipe which failed, will be considered in compliance. If any of the additional sections fail, the entire lot will be considered non-compliant and shall not be used.

5. Coating and Lining Repair of Holidays and Cut Ends

- a. Holidays and cut ends shall be repaired by solvent cleaning, roughening with coarse sand paper, and application of brushable 2-component material recommended by the manufacturer for such purposes. Overlap the acceptable coating and lining at least one inch in all directions. Mix repair material and apply in accordance with the manufacturer's recommendation.

\$# _____

NTS: The DESIGN CONSULTANT shall prepare a list of candidate manufacturers for the proposed coating/lining material from which list the OWNER will select and approve the polyurethane manufacturer for the project.

_____\$

E. **Polyurethane Manufacturers**

1. []
2. []
3. [or equal]

F. **Qualifications, Approval, and Documentation of Polyurethane Manufacturers**

1. **Qualifications:** The polyurethane manufacturer shall have a record of at least one application of the proposed coating/lining material on a successfully performing steel pipe installation of comparable size and complexity constructed in the recent past.
2. Approval

- a. Bidders shall submit the name and documented qualifications of the manufacturer proposed for the polyurethane material. The OWNER will review and approve the proposed selection.
- b. Documentation to be submitted CONTRACTOR
 - (1) Documentation of at least one steel pipe project constructed in the recent past and successfully performing under similar service conditions.
 - (2) The name, telephone number, and address of the owner and completion date and location for the project listed above.
 - (3) The name, telephone number, and address of the firm which applied the polyurethane in the project listed above.
 - (4) Descriptive literature, including Material Safety Data Sheet, for the proposed material.

PART 1 -- EXECUTION

3.1 INSTALLATION OF PIPE

- A. When the pipe is being laid, it shall be turned and placed where possible, so that any slightly damaged portion will be on top. The damaged area shall be repaired for the protection of any exposed steel. All damaged areas shall be repaired using materials and methods acceptable to the CONSTRUCTION MANAGER.
- B. Moderate deflections and long radius curves may be made by means of beveled joint rings, by pulling standard joints, by using short lengths of pipe, or a combination of these methods; provided that pulled joints shall not be used in combination with bevels. The maximum total allowable angle for beveled joints shall be 5 degrees per pipe joint. Bevels shall be provided on the bell ends. Mitering of the spigot ends will not be permitted. The maximum allowable angle for pulled joints shall be in accordance with the manufacturer's recommendations or the angle which results from a 3/4-inch pull out from normal joint closure, whichever is less. All horizontal deflections or fabricated angles shall fall on the alignment. [In congested city streets or at other locations where underground obstructions may be encountered, the chord produced by deflecting the pipe shall be no further than 6 inches from the alignment indicated.]
- C. All vertical deflections shall fall on the alignment and at locations adjacent to underground obstructions, points of minimum earth cover, and pipeline outlets and structures. The pipe angle points shall match the angle points indicated.
- D. For pipe 42 inches in diameter and larger, pipe struts shall be left in place until backfilling operations have been completed. After the backfill has been placed, the struts shall be removed and shall remain the property of the CONTRACTOR. Struts in pipe smaller than 42 inches may be removed immediately after laying, provided, that the deflection of the pipe during and after backfilling does not exceed that indicated.
- E. The openings of all pipe and specials that have been lined in the shop shall be protected with suitable bulkheads to maintain a moist atmosphere and to prevent unauthorized access by persons, animals, water, or any undesirable substance. The bulkheads shall be so designed to prevent drying out of

the interior of the pipe. The CONTRACTOR shall introduce water into the pipe to keep the mortar lining moist where moisture has been lost due to damaged bulkheads.

3.2 FIELD TESTING

- A. Field testing shall conform to the requirements of Section 02666.
- B. All exterior surface coatings shall be inspected electrically immediately before the pipe is lowered into the trench, following the same requirements for factory inspection procedure and voltage indicated above for the protective material. All holidays shall be repaired before the pipe is placed in the trench.

3.3 RUBBER GASKETED JOINTS

- A. **Rubber Gasketed Joints:** Immediately before jointing pipe, the spigot end of the pipe shall be thoroughly cleaned, and a clean rubber gasket lubricated with an approved vegetable-based lubricant shall be placed in the spigot groove. The volume of the gasket shall be "equalized" by moving a metal rod between the gasket and the spigot ring around the full circumference of the spigot ring. The bell of the pipe already in place shall be carefully cleaned and lubricated with a vegetable-based lubricant. The spigot of the pipe section shall then be inserted into the bell of the previously laid pipe section and be telescoped into its proper position. Tilting of the pipe to insert the spigot into the bell will not be permitted. After the pipe units have been joined, a feeler gauge shall be inserted into the recess and moved around the periphery of the joint to detect any irregularity in the position of the rubber gasket. If the gasket cannot be "felt" all around, the joint shall be disassembled. If the gasket is undamaged, as determined by the CONSTRUCTION MANAGER, it may be reused, but only after the bell ring and gasket have been cleaned and relubricated.

3.4 WELDED JOINTS

- A. **General:** Field welded joints shall be in accordance with ANSI/AWWA C206.
- B. Where exterior welds are performed, adequate space shall be provided for welding and inspection of the joints.
- C. During installation of welded steel pipe in either straight alignment or on curves, the pipe shall be laid so that the lap joint clearance, at any point around the circumference of the joint, shall comply with the requirements of AWWA C 206. Unless double fillet welds are indicated, field welded lap joints may, at the CONTRACTOR'S option, be made on either the inside or the outside of the pipe.
- D. Butt straps, where used or required, shall be a minimum of 6 inches wide, the same thickness as the pipe wall and shall provide for a minimum of 3/4-inch lap at each pipe joint. The pipe ends shall be cut straight on joints where butt straps are used for realignment, adjustment, or deflection, and fillet welds shall be made as indicated.
- E. After the pipe and pipe joint are properly positioned in the trench, the section of pipe between joints shall be backfilled to at least one foot above the top of the pipe. Care shall be exercised during the initial backfilling to prevent movement of the pipe and to prevent any backfill material from being deposited on the joint.
- F. To control temperature stresses, the unbackfilled joint areas of the pipe shall be shaded from the direct rays of the sun by the use of properly supported awnings, umbrellas, tarpaulins, or other suitable materials for a minimum period of 2 hours prior to the beginning of the welding operation and until the weld has been completed. Shading materials at the joint area shall not rest directly on

the pipe but shall be supported to allow air circulation around the pipe. Shading of the pipe joints need not be performed when the ambient air temperature is below 45 degrees F.

- G. Prior to the beginning of the welding procedure, any tack welds used to position the pipe during laying shall be removed. Any annular space between the facing surfaces of the bell and spigot shall be equally distributed around the circumference of the joint by shimming, jacking, or other suitable means. The weld shall then be made in accordance with ANSI/AWWA C206. Where more than one pass is required, each pass except the first and final one shall be peened to relieve shrinkage stresses; and all dirt, slag, and flux shall be removed before the succeeding bead is applied.
- [H. As soon as practicable after welding of each joint, all field-welded joints shall be tested by the liquid penetrant inspection procedure conforming to the requirements of ANSI/ASTM E 165 under Method "B" and "Leak Testing." All defects shall be chipped out, rewelded and retested. Upon retest, the repaired area shall show no leaks or other defects.]
- [I. Following testing of the joint, the exterior joint spaces shall be coated in accordance with these specifications after which backfilling may be completed.]

3.5 JOINT COATING AND LINING

- A. **General:** The interior and exterior joint recesses shall be thoroughly wiped clean and all water, loose scale, dirt and other foreign material shall be removed from the inside surface of the pipe.
- B. **Joint Coating:** Joints for coal tar enamel-coated pipe shall be primed and wrapped with 2 thicknesses of 12-inch wide elastomeric joint tape, Type II per ANSI/AWWA C209. The total thickness of the tape wrap shall be at least 70 mils and shall be installed free of wrinkles with all laps bonded. All primer and joint tape shall be compatible with the line pipe coating.
- C. All tape-coated joints for enamel-coated pipe shall be tested by the CONSTRUCTION MANAGER with an electrical flaw detector capable of at least a 12,000 volt output, furnished by the CONTRACTOR. The tests shall be made using a voltage of 6,000 to 7,000 volts. Any holidays found shall be repaired by the CONTRACTOR at no expense to the OWNER.
- D. **Coating Repair:** Coating repair shall be made using tape and primer conforming to ANSI/AWWA C209. When visual inspection shows a portion of the tape-wrap system has sustained physical damage, the damaged area shall be subjected to an electrical holiday test of 6,000 to 7,000 volts.
- E. Following repair of the damaged area if the holiday test indicates a holiday still exists, the inner wrap shall be exposed and the exposed area shall be wiped clean with xylol solvent, or equal, and the area coated with tape primer. A patch of 35-mil thick cold-applied tape of sufficient size to cover the damaged area, plus a minimum lap of 2 inches in all directions, shall then be applied. The patched area shall again be tested for holidays. If none are detected, a second layer of 35-mil thick tape shall then be applied over the first patch. The second layer of tape shall overlap the first layer a minimum of 2 inches in all directions.
- F. When the area tests show no holiday, a notation shall be applied to the area indicating the test is satisfactory.
- G. **Joint Lining:** After the backfill has been completed to final grade, the interior joint recess of mortar lined pipe shall be filled with mortar of stiff consistency mixed in proportions of one part cement to 2 parts sand. The mortar shall be tightly packed into the joint recess and troweled flush with the interior surface, and all excess shall be removed. At no point shall there be an indentation or projection of the mortar exceeding 1/16-inch. For pipe smaller than 24 inches in diameter, before

the spigot is inserted into the bell, the bell shall be daubed with mortar containing one part cement to 2 parts sand. The spigot end then shall be forced to the bottom of the bell and excess mortar on the inside of the joint shall be swabbed out.

- [H. **Cement-Mortar Lining, Field-Applied:** For pipe diameters of [60] in or larger, the CONTRACTOR may construct the cement-mortar lining in-place. The application of in-place cement-mortar lining shall be in accordance with ANSI/AWWA C602.
- I. The lining machine shall be of a type that has been used successfully for a similar size of pipe. The CONTRACTOR shall perform all work in a thorough and workmanlike manner by trained personnel, under the supervision of personnel experienced in machine application of cement-mortar lining to pipelines of size comparable to this work.
- J. Curing of the in-place cement-mortar lining shall be in accordance with ANSI/AWWA C602. The CONTRACTOR shall provide additional protective devices as required to ensure that the airtight covers, which maintain a moist condition in the pipeline, are not damaged.
- K. Defective areas encompassing the full diameter of the pipe shall be replaced by machine wherever the length measured along the pipe centerline is greater than 5 feet; otherwise defective areas may be replaced by hand.]

3.6 INSTALLATION OF PIPE APPURTENANCES

- A. **Protection of Appurtenances:** Where the joining pipe is coal tar enamel-coated, buried appurtenances shall be coated with cold-applied tape in accordance with ANSI/AWWA C209, Type II.
- B. **Installation of Valves:** All valves shall be handled in a manner to prevent any injury or damage to any part of the valve. All joints shall be thoroughly cleaned and prepared prior to installation. The CONTRACTOR shall adjust all stem packing and operate each valve prior to installation to insure proper operation.
- C. All buried valves shall be coated and protected in accordance with Section 09800.
- D. All valves shall be installed so that the valve stems are plumb and in the location shown.
- E. **Installation of Flanged Joints:** Before the joint is assembled, the flange faces shall be thoroughly cleaned of all foreign material with a power wire brush. The gasket shall be centered and the connecting flanges drawn up watertight without unnecessarily stressing the flanges. All bolts shall be tightened in a progressive diametrically opposite sequence and torqued with a suitable, approved and calibrated torque wrench. All clamping torque shall be applied to the nuts only.
- F. All buried flanges shall be coated and protected in accordance with Section 09800.
- G. **Insulated Joints:** Insulated joints and appurtenant features shall be made by the CONTRACTOR as shown on the Drawings. The CONTRACTOR shall exercise special care when installing these joints to prevent electrical conductivity across the joint. After the insulated joint is completed, an electrical resistance test will be performed by the CONSTRUCTION MANAGER. Should the resistance test indicate a short circuit, the CONTRACTOR shall remove the insulating units to inspect for damage, replace all damaged portions, and reassemble the insulating joint. The insulated joint shall then be retested to assure proper insulation.

- H. **Flexible Coupled Joints:** When installing flexible couplings, care shall be taken that the connecting pipe ends, couplings and gaskets are clean and free of all dirt and foreign matter with special attention being given to the contact surfaces of the pipe, gaskets and couplings. The couplings shall be assembled and installed in conformity with the recommendation and instruction of the coupling manufacturer.
- I. Wrenches used in bolting couplings shall be of a type and size recommended by the coupling manufacturer. Coupling bolts shall be tightened so as to secure a uniform annular space between the follower rings and the body of the pipe with all bolts tightened approximately the same amount. Diametrically opposite bolts shall be tightened progressively and evenly. Final tightening shall be done with a suitable, approved and calibrated torque wrench set for the torque recommended by the coupling manufacturer. All clamping torque shall be applied to the nut only.
- J. Upon completion of the coupled joint, the coupling and bare metal of the pipe shall be cleaned, primed, and protected in accordance with the requirements of Section 09800.

3.7 CORROSION CONTROL

- A. **Joint Bonding/Test Stations:** Joints shall be bonded in accordance with the details indicated. The pipe shall be cleaned to bare bright metal at the point where the bond is installed. The pipe manufacturer shall be responsible for determining and implementing a suitable procedure and schedule for installation of bonding—field versus factory versus combination—in manner that the corrosion resistance of the lining and coating is not degraded by the bonding process. It may involve welding joint bonding pads, or welding the bonding wires in the factory before applying the lining and coating specified and/or may involve patching impaired areas in the factory or the field. In addition, test stations shall be installed where shown.
- B. **Bonding and Electrical Continuity:** All unwelded pipe joints shall be bonded for electrical conductivity in accordance with the details indicated. The CONTRACTOR shall furnish all materials required for joint bonding and test station installations. 2½"x 2"x 3/8" thick steel pads similar to the pipe material shall be welded on both ends of the pipe prior to lining and coating. Following welding of the bond wires to the pipe, the exterior coating shall be repaired per Section 15025.
- [C. **Cathodic Protection:** Cathodic protection shall be provided in accordance with Section 15025. Corrosion mitigation and testing materials, such as an impressed current cathodic protection system, magnesium anodes, reference electrodes, and test lead wires shall be provided as indicated.]

** END OF SECTION **